

# **TOWN OF GARNER**

## **RETENTION POND DESIGN CRITERIA**

August 22, 1993

Retention ponds "wet ponds" are intended to enhance the quality of stormwater runoff from developed sites. In addition to stormwater quality, stormwater management with respect to runoff quantity is normally a by-product achieved with retention ponds. Retention ponds are like detention ponds and sediment basins in that the facility consists of a water impoundment area, a primary spillway (normally a riser and barrel arrangement) and an emergency spillway. Unlike detention ponds and sediment basins, however, retention ponds are designed to maintain a permanent pool of water in the pond. A brief description of general design criteria for retention ponds is presented below.

**POND DEPTH** - Retention ponds should be designed with an average depth of between 3 feet and 6 feet as measured from the permanent pool elevation. This depth is exclusive of the required sediment storage area.

**POND CONFIGURATION** - Pond shape should minimize dead storage areas. Average length of flow for the main inflow points should be at least twice the distance as the effective width. A forebay shall be included at all significant inflow points to encourage early settling. This allows draining of only a portion of the pond in order to excavate accumulated sediment. The forebay may be established by a weir. The forebay volume should equal about 10%-20% of the pond volume. A sketch showing the general layout of a retention pond is presented at the end of this document.

**PERMANENT POOL SURFACE AREA** - The surface area of the permanent pool (SA) is dependent upon (1) the acreage of the area draining to the pond (DA), (2) the average depth of the pond, and (3) the percentage of impervious surface in the drainage basin. It should be noted that the calculation of the drainage area size includes not only on-site areas but also all off-site acreage which will drain to the pond. Likewise, the calculations for percentage of impervious surface should provide for estimated future off-site impervious surfaces which will drain to the pond as well as proposed on-site development. Tables listing the minimum permanent pool surface areas are presented in appendix A.

**SEDIMENT STORAGE** - Storage is required in the bottom of the pond for sediment accumulation. The Simple Method (Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, Schueler, 1987) should be used to determine the amount of sediment storage needed. Based upon a 20 year design life the Simple Method can be approximated by the following formula:

$$L_{20} = 2.3 CA (.009 I + .05)$$

where:

$L_{20}$  = Sediment storage volume (CFT)

C = Pollutant Concentration (mg/l) see chart, appendix A

A = Drainage area (acres)

I = Impervious Surface Ratio (%)

As a minimum the sediment storage layer should be no less than 0.5 feet deep.

**EXTENDED DETENTION STORAGE** - In addition to the permanent pool, the retention pond should also provide for the temporary storage of the runoff resulting from a 1-inch rain event in order to provide for extended detention. The orifice used to drain the temporary storage should withdraw water at least one foot below the permanent pool surface. The orifice should be designed to release the temporary storage over a 24-48 hour period. The extended detention storage volume should be determined by using the rational method or TR-55 (Soil Conservation Service, U. S. Department of Agriculture, Jan., 1975) to calculate the depth of runoff. The minimum depth of the extended detention storage layer shall be 0.5 feet.

**PRIMARY SPILLWAY** - In addition to water quality, the retention pond will in some cases be used as a stormwater quantity control device via detention. As such, the primary spillway should be sized based upon the 10 year storm in a predeveloped condition. The temporary stormwater storage may be taken into account as a part of the stormwater routing procedure. The routing procedure should be based upon the Small-Watershed Hydrograph-Formulation Method (Malcom, 1989) or other methods approved by the Engineering Department.

The elevation of the primary spillway should be set at or above the level of the required temporary stormwater storage elevation. If a riser/barrel spillway is used, a trash rack or hood should be installed in areas which would be prone to clogging. Design of the riser/barrel system should be in accordance with standard sediment basin design guidelines. In order to reduce future maintenance problems the barrel and riser should be constructed of RCP or PVC pipe. The riser/barrel system should provide for some type of drain to allow for the quick (less than 24 hours) removal of all water from the retention pond in areas where gravity flow can be obtained.

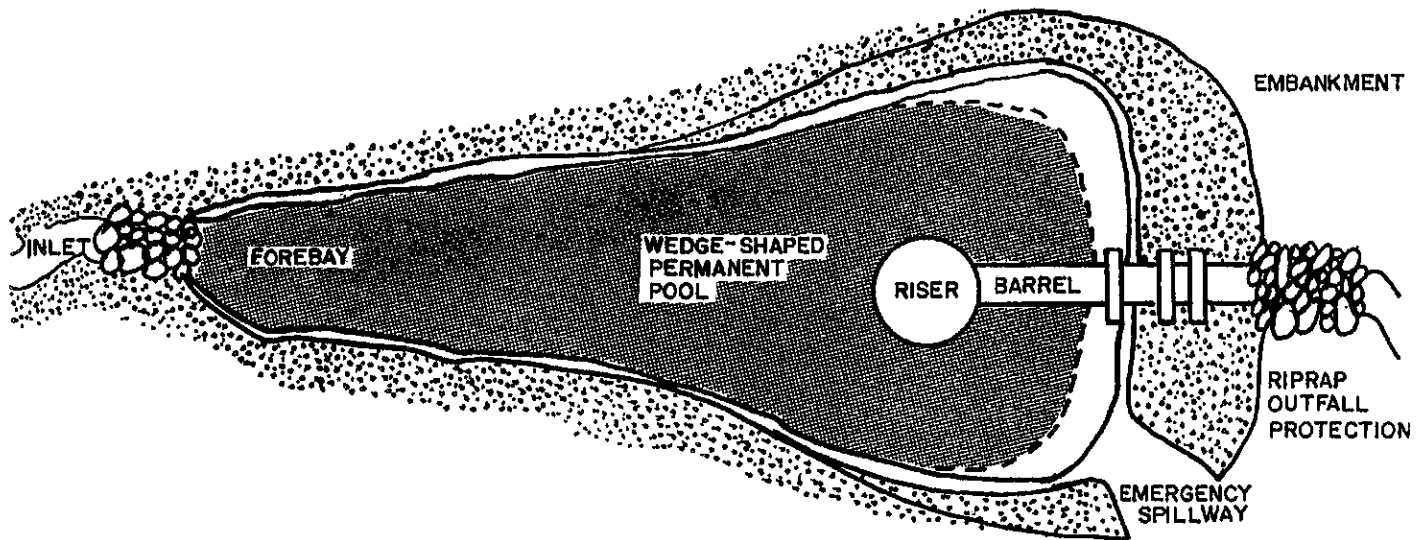
**EMERGENCY SPILLWAY** - An emergency spillway should be constructed as a part of the retention pond to handle stormwater runoff associated with the 100 year rain event. The combined capacity of the primary spillway and the emergency spillway should equal or exceed the 100 year storm peak flow. The invert of the emergency spillway should be set at least 0.10 feet above the

elevation of the Extended Detention Storage level or the level of the storage required for the 10 year storm, whichever is higher. The design of the spillway should be in accordance with standard sediment basin design.

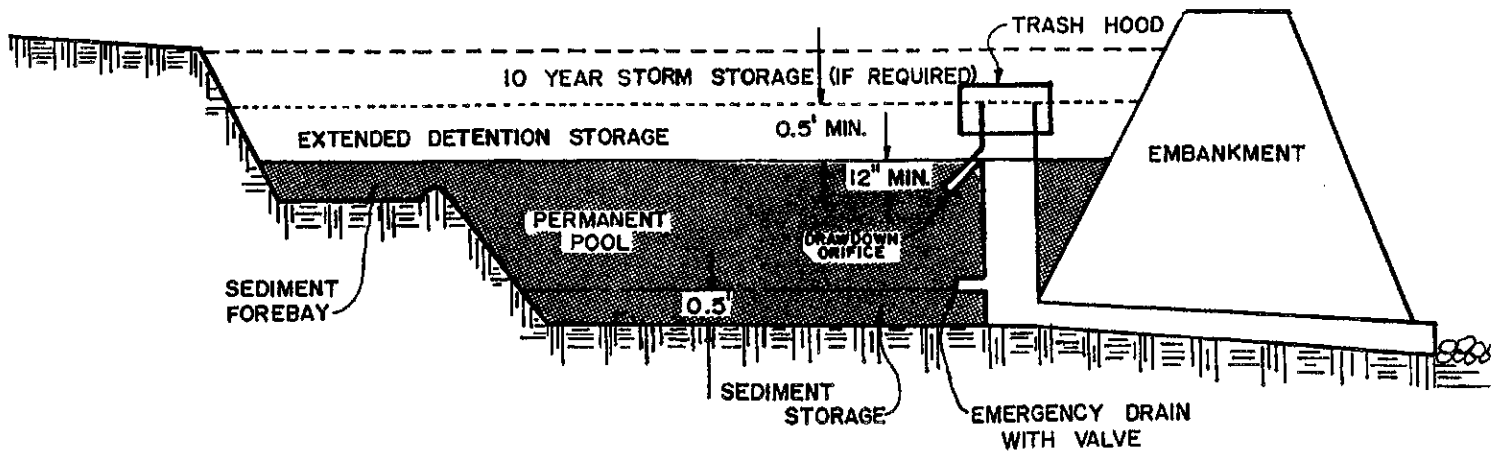
**EMBANKMENT** - The embankment section, in addition to creating the impoundment, will be used to provide access to the retention pond for inspection and maintenance purposes. As such, the top of the embankment should be constructed in a manner satisfactory to provide access to vehicular traffic. The width of the embankment section at the top should be at least ten feet. The embankment should have at least one foot of freeboard above the design flow level of the emergency spillway. In order to provide for possible consolidation of the embankment section, extra fill should be allowed on the embankment during construction. Overall construction of the embankment should be in accordance with SCS Technical Guideline #378-1, Ponds.

**CERTIFICATION** - All ponds shall be designed by a North Carolina Registered Professional Engineer and the plans shall be sealed accordingly. "As-built" surveys will be required at the completion of construction along with a certification from the design Engineer stating that the pond has been constructed as designed.

**SURVEY BENCH MARK** - In order to assist with construction, "as-built" surveys, and future sediment accumulation monitoring a vertical bench mark shall be established in the immediate vicinity of the retention pond. The bench mark should be located so that the outlet structures are visible from one "set up." The bench mark should not be established in a fill area. A precise, detailed description of the location of the bench mark along with the elevation to the nearest 0.1 ft. should be indicated on the "as-built" plans.



PLAN



PROFILE

## **APPENDIX A**

## PERMANENT POOL SURFACE AREA SIZING REQUIREMENTS

The numbers in the chart below represent the required permanent pool surface area (SA) as a percentage of the total area draining to the pond (DA) needed to achieve an 85% pollutant removal. The chart is based on the amount of impervious cover as a percentage of the drainage area and the average depth of the permanent pool of the pond, excluding sediment storage. Impervious percentages are in the left hand column of the chart and depths are given across the top of the table.

TABLE A-1

Impervious %	Permanent Pool Depths (feet)						
	3.0	3.5	4.0	4.5	5.0	5.5	6.0
10	0.59	0.54	0.49	0.47	0.43	0.39	0.35
20	0.97	0.88	0.79	0.75	0.70	0.65	0.59
30	1.34	1.20	1.08	1.03	0.97	0.91	0.85
40	1.73	1.58	1.43	1.36	1.25	1.14	1.03
50	2.00	1.82	1.73	1.64	1.50	1.40	1.33
60	2.39	2.09	2.03	1.87	1.66	1.56	1.51
70	2.75	2.44	2.27	2.12	1.96	1.87	1.79

To determine the required permanent pool size use the following steps:

1. Calculate the percent impervious cover of the site draining to the pond.
2. Determine the average permanent pool depth (or select a depth for comparison purposes). Average permanent pool depth is determined by dividing the permanent pool volume by the permanent pool surface area.
3. Go to the above chart with the impervious percentage found in 1. Go across the chart at this impervious percentage until you are under the appropriate permanent pool depth and read the value in the table. The number in the chart is given as a percent (%). If your impervious percentage or pond depth is between one of the values given you may interpolate between values or you may use the equations listed below which approximate the values in the table.

For pool depth =

$$\begin{aligned}
 3.0 \text{ feet, SA/DA} &= .0356 (\% \text{ impervious}) + .26 \text{ --- (EQ A1)} \\
 3.5 \text{ feet, SA/DA} &= .0312 (\% \text{ impervious}) + .26 \text{ --- (EQ A2)} \\
 4.0 \text{ feet, SA/DA} &= .0303 (\% \text{ impervious}) + .20 \text{ --- (EQ A3)} \\
 4.5 \text{ feet, SA/DA} &= .0279 (\% \text{ impervious}) + .21 \text{ --- (EQ A4)} \\
 5.0 \text{ feet, SA/DA} &= .0251 (\% \text{ impervious}) + .21 \text{ --- (EQ A5)} \\
 5.5 \text{ feet, SA/DA} &= .0241 (\% \text{ impervious}) + .17 \text{ --- (EQ A6)} \\
 6.0 \text{ feet, SA/DA} &= .0237 (\% \text{ impervious}) + .12 \text{ --- (EQ A7)}
 \end{aligned}$$

4. To determine the required surface area of the pond take the number from the chart, divide by 100 and multiply this number by the contributing drainage area.

## SEDIMENT STORAGE

$$L_{20} = 2.3 CA (.009 I + .05)$$

where:

$L_{20}$  = Sediment Storage Volume (CFT)  
 $C$  = Pollutant Concentration (mg/l)  
 $A$  = Drainage Area (acres)  
 $I$  = Impervious Surface Ratio (%)

### Watershed Area vs. Pollutant Concentration

Figure A1

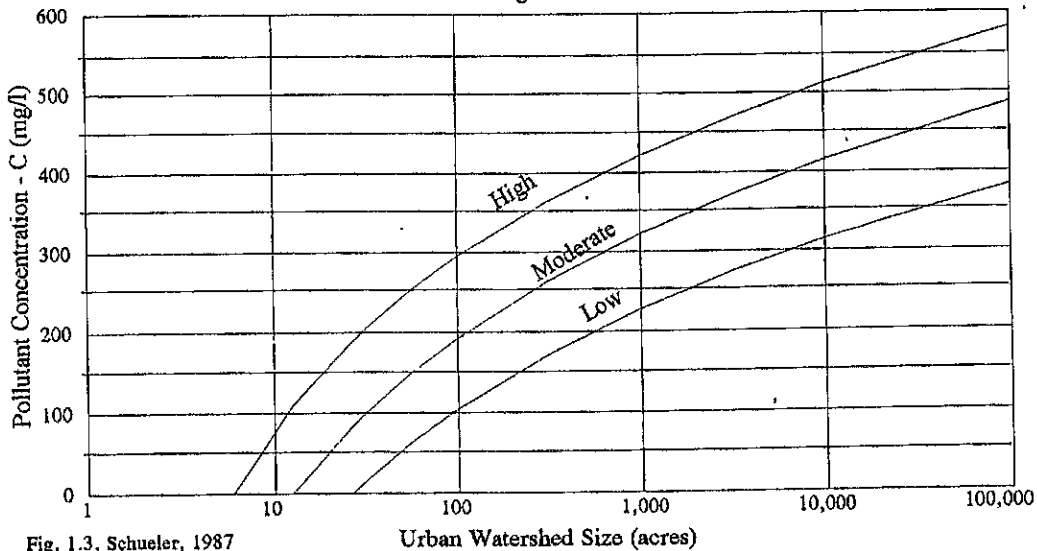


Fig. 1.3, Schueler, 1987

Table A-2.

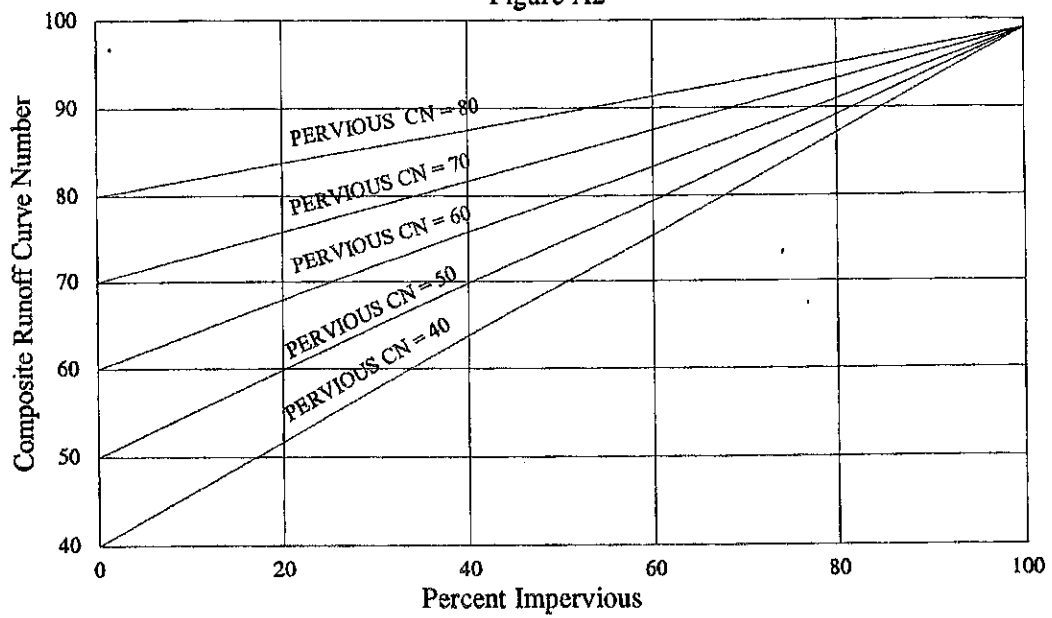
Watershed Channel Network Condition

CRITERIA	LOW C	MODERATE C	HIGH C
STABILITY CONDITION OF CHANNEL	vegetated swales or storm sewers	intermediate	open channel, cut banks alternating w/channel sandbars, fallen trees
CHANNEL SEDIMENT STORAGE	small deposits in storm drains, stabilized land use	"	large silt or clay deposits, evidence of recent or ongoing construction, water becomes murky after disturbing bottom
STREAM VELOCITY	low slope, low imperviousness	"	high slope, high watershed imperviousness

Fig. 1.2, Schueler, 1987

Note: 1. Use high C curve unless site conditions warrant use of moderate C curve.  
 2. Depth of sediment storage pool shall not be less than 0.5 feet.

Percentage of Impervious Areas vs. Composite CN's for given Pervious Area CN's  
Figure A2



**Table A-3. Runoff Curve Numbers (CN)**

LAND USE DESCRIPTION	HYDROLOGIC SOIL GROUP <sup>3</sup>			
	A	B	C	D
Cultivated land <sup>1</sup> : without conservation treatment	72	81	88	91
with conservation treatment	62	71	78	81
Pasture or range land: poor condition	68	79	86	89
good condition	39	61	74	80
Meadow: good condition	30	58	71	78
Wood or Forest land: thin stand, poor cover, no mulch	45	66	77	83
good cover <sup>2</sup>	25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.				
good condition: grass cover on 75% or more of the area	39	61	74	80
fair condition: grass cover on 50% to 75% of the area	49	69	79	84
Commercial and business areas (85% impervious)	89	92	94	95
Industrial districts (72% impervious)	81	88	91	93
Residential: <sup>3</sup>				
Average lot size      Average % Impervious <sup>4</sup>				
1/8 acre or less      65	77	85	90	92
1/4 acre      38	61	75	83	87
1/3 acre      30	57	72	81	86
1/2 acre      25	54	70	80	85
1 acre      20	51	68	79	84
Paved parking lots, roofs, driveways, etc.	95	95	95	95
Streets and roads:				
paved with curbs and storm sewers	95	95	95	95
gravel	76	85	89	91
dirt	72	82	87	89

<sup>1</sup>For a more detailed description of agricultural land use curve numbers refer to National Engineering Handbook, Section 4, Hydrology, Chapter 9, Aug. 1972.

<sup>2</sup>Good cover is protected from grazing and litter and brush cover soil.

<sup>3</sup>Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

<sup>4</sup>The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

<sup>5</sup>Downgrade hydrologic soil group one step (raise CN value) when pervious surfaces have been exposed to heavy construction equipment or where pervious areas will be barren with little sod established.

## **APPENDIX B**

$$S = \frac{1000}{CN} - 10 = \frac{1000}{83} - 10 = 2.05$$

$$\text{depth of runoff } (Q) = \frac{(P - 0.2S)^2}{P + 0.8S}$$

P = 1" Rainfall Event

$$Q = \frac{(1 - 0.2 \times 2.05)^2}{1 + 0.8 \times 2.05} = 0.13 \text{ inches} = 0.011 \text{ feet}$$

Volume of Runoff =

$$100 \text{ Acres} \times 43,560 \text{ SFT/AC} \times 0.011 \text{ feet} = 47,916 \text{ CFT}$$

Depth of Extended Storage = The pond site is such that the surface area increases significantly as the elevation above the permanent pool increases. At one foot above the permanent pool the surface area is 187,000 SFT. The depth of extended detention is approximately equal to:

$$\frac{58,806 \text{ SFT} + 187,000 \text{ SFT}}{2} \times 1 \text{ ft depth} = 122,903 \text{ CFT}$$

$$\frac{47,916 \text{ CFT}}{122,903 \text{ CFT}} = .39 \text{ feet}$$

Use Minimum Depth of .5 feet

Extended Detention Storage Depth = 0.5 feet

Note: This project is located near Lake Benson and no development is located downstream of the pond. As such, no flood storage is needed.

## Example 2

Design a retention pond for a proposed shopping center given the following information:

Drainage Area to Retention Pond = 30 acres  
Impervious Surface Area = 70%  
Soil Type = Appling/Cecil

### DETERMINE PERMANENT POOL SURFACE AREA

Assume a Permanent Pool Average Depth of 4.5'  
From Table A-1, for I = 70%  
SA/DA = 2.12%  
30 Acres Drainage Area x 2.12% = .63 Acres = 27,704

Required Pool Surface Area = 27,704 SFT

Check Average Depth: The volume of the proposed pond is 126,000 CFT at the level where the surface area equals the required 27,704 SFT. This volume does not include sediment storage.

$126,000 \text{ CFT} / 27,704 \text{ SFT} = 4.55' \approx 4.5'$  therefore o.k.

### DETERMINE SEDIMENT STORAGE

$$L_{20} = 2.3 \text{ CA } (.009 \text{ I} + .05)$$

On this project the retention pond drainage area is basically limited to the project site with no off-site drainage. All drainage on the site will be conveyed in underground storm drains and well maintained grass lined swales. Ditch slopes are relatively flat with very little potential for erosion. Due to the type of facility proposed there will be almost no future land disturbance after initial construction is completed. Accordingly, instead of using the high 'C' condition, a low 'C' condition is more appropriate for this project.

From Figure A-1, for 30 acre drainage area and low 'C' condition

$$C = 25 \text{ mg/l}$$

$$I = 70\%$$

$$L_{20} = 2.3 \times 25 \times 30 (.009 \times 70 + .05) = 1,173 \text{ CFT}$$

At the bottom of the pond the surface area is 15,620 SFT  
Sediment Storage Depth =  $1,173 \text{ CFT} / 15,620 \text{ SFT} = .08 \text{ feet}$

Use Minimum Depth of 0.5 feet

Sediment Storage Layer = 0.5 feet

## DETERMINE EXTENDED DETENTION STORAGE

Determine CN value

The site soils are appling and cecil which would normally be classified as a hydrological soil group B (see TR-55, appendix B). However, the majority of the project site will be graded and exposed to heavy construction equipment. Therefore, hydrological soil group C will be used.

Table A-3 cannot be used directly to determine the CN number as the table assumes 85% impervious cover whereas this project will only have a 70% impervious cover.

From Table A-3, for lawns and open spaces with hydrological soil group C, CN = 74

From Figure A-2, for 70% impervious and pervious CN = 74,  
Adjusted CN = 91

$$S = \frac{1000}{CN} - 10 = \frac{1000}{91} - 10 = .99$$

$$\text{depth of runoff } (Q) = \frac{(P - 0.2S)^2}{P + 0.85}$$

P = 1" Rainfall Event

$$Q = \frac{(1 - 0.2 \times .99)^2}{1 + 0.8 \times .99} = .36 \text{ inches} = .03 \text{ feet}$$

Volume of Runoff =

$$30 \text{ Acres} \times 43,560 \text{ SFT/AC} \times .03 \text{ feet} = 39,204 \text{ CFT}$$

Depth of Extended Storage - The pond site is such that the surface area increases only slightly as the elevation above the permanent pool increases. Therefore, the depth of extended storage is approximately equal to:

$$\frac{\text{Required Storage} = 39,204 \text{ CFT}}{\text{Permanent Pool Surface Area} = 27,704 \text{ SFT}} = 1.42 \text{ feet, say 1.5 ft.}$$

Extended Detention Storage Depth = 1.5 feet

Note: The increased runoff from this project may adversely affect a developed area immediately downstream. As such, flood storage for the 10 year storm must be designed for this pond.